# Digital Public-Administration Research Drawing from Bayesian Inspiration : Latent Trait Scaling and Topic Modeling Examination of Budgetary Legislation in Thirteen Countries

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# Digital Public Administration Research Drawing from Bayesian Inspiration: Latent Trait Scaling and Topic Modeling Examination of Budgetary Legislation in Thirteen Countries


## ABSTRACT

This article extends the methodological and empirical scope of public administration research by means of two Bayesian methods of examination, namely unsupervised latent trait scaling and topic modeling. The article applies these methods to examine government budgeting in thirteen Western countries, utilizing budgetary legislation as the research material. According to the results, at one end of the latent trait scale we find overseas inheritors of Britain's common law legal system, Canada, Australia, and New Zealand, and at the other end two representatives of civil law of the Napoleonic subtype, Italy and Spain. The other countries situate themselves in intermediate positions between the extremes. The topic modeling indicates three reasonably homogeneous groups of countries: the three overseas inheritors of common law and more weakly the United Kingdom, three countries representing the Napoleonic heritage, and German-speaking and Nordic countries. In general, the article and its results emphasize the available good opportunities to extend Bayesian-inspired research in this research field.


## INTRODUCTION

This article draws from Bayesian inspiration to examine an element of public administration in its financial aspect, comprised of government budgeting. The article indeed refers to "Bayesian inspiration" only, as absolute consensus is lacking as to what counts as Bayesian (see Gelman and Shalizi 2013 and other authors in the same journal issue). This article strives towards two related Bayesian-inspired methodological objectives: first, carrying out what is called "unsupervised latent trait scaling" and next, engaging in what is known as "topic modeling."

The research material is comprised of legal texts passed in thirteen Western countries to regulate institutional structures, procedures and classifications of federal or national government budgeting: Australia, Austria, Canada, Estonia, Finland, France, Iceland, Italy, the Netherlands, New Zealand, Spain, Sweden, and the United Kingdom (Table 1). Accordingly, this article joins the long but nowadays rather thin line of research that does not shy away from ascribing importance to legal aspects of public administration (Wright 2011; within public administration research interestingly, see Painter and Peters 2010).

Within Bayesian-inspired research this article technically represents extensions of machine learning studies, also known as computational studies. The first research task comprises unsupervised scaling (Slapin and Proksch 2008) of the research material in order to discern latent, polarized traits in text documents and in the countries that these texts represent. The second research task is comprised of carrying out basic topic modeling using of the same research material (Grimmer and Stewart 2009) in order to discern interesting topics in the corpus of texts, each of which represents one of the thirteen countries. This article does not aim to add to the research techniques it applies by means of introducing novel algorithms, but to expand the scope of existing techniques, suggest them new utilization, and implement these suggestions in an empirical study. More generally, the article advanced digital methods of political and related research including public administration research.

The next section elaborates the epistemological and other legitimation for this article, and proposes the research hypotheses. The two subsequent sections introduce the research methods and the research material. The following two sections report the empirical examination: first, the unsupervised scaling of latent traits, and next, the topic modeling. The last section consists of a summary and a discussion.

TABLE 1 ABOUT HERE

## LEGITIMATION OF THIS STUDY, AND THE RESEARCH HYPOTHESES

### Epistemological legitimation

From the point of view epistemology – dealing with what can be known in principle – this article joins research that sees problems in "frequentist" interpretations of probability, meaning probability understood in terms of relative frequencies of the events examined on the assumption that these events are drawn from a large number of trials or other relevant cases. Some authors try to improve the "frequentism" from within by means of improved specification of statistical models or applications of principles of experimental research beyond its proper domain as narrowly understood (see several of the articles in Brady and Collier 2010). Some other authors find in set theory the basis for empirical research that avoids the pitfalls of frequentism (Goertz and Mahoney 2012). Further alternatives comprise approaches informed by Bayesian thinking, more metaphorically (Beach and Pedersen 2013), or without shying away from formalization and quantification (Gill and Witko 2013). Whether metaphorical or literal, Bayesian-inspired approaches build upon what is known as Bayes's theorem. Refined ways to express it exist, but a simplified form suffices:

$$P(A|B) \propto P(A) \times P(B|A) \quad (1)$$

Let us assume that we are collecting evidence, B, about whether an event, A, occurs. The probability of A, P(A), before B becomes available, comprises the Bayesian *prior*. Formula (1) expresses the probability of A after B has become available, P(A|B), the Bayesian *posterior*. The formula expresses P(A|B) to be proportional (expressed by the sign $\propto$) to the prior P(A) times the Bayesian *likelihood*, P(B|A), which comprises the probability of acquiring the evidence B on the condition that the event A occurs. Briefly, the posterior is proportional to the prior times the likelihood, and the examination advances from what is known, the prior, via estimation by means of the likelihood to the latent, the posterior.

**Further legitimation of this study**

There are other than epistemological reasons for this article. One of these is comprised of challengse to cultivate high and up-to-date standards in public administration research without subjection to demands to propose quick solutions to acute problems by means of routine methods. Bayesian-inspired latent trait analysis first appeared in political science research in the shape of supervised latent scaling (Laver, Benoit and Garry, 2002), and next as unsupervised scaling (Proksch and Slapin 2008), and in some respects these two types of scaling have been joining their forces more lately (e.g., Lowe and Benoit 2013). The Bayesian-inspired methods of topic modeling found their way into political science at about the same time as unsupervised scaling (Grimmer and Stewart 2009). More than latent trait scaling (Charbonneau 2009), topic modeling has also been applied reasonably close to public administration research thus far (Clark and Lauderdale 2010; Fienberg 2011; DiMaggio, Nag, and Blei 2013; Levy and Franklin 2013).

Another non-epistemological reason for this article concerns research politics. In some countries including the author's own, public administration scholars may find themselves crowded out from domains of interesting approaches and interesting topics by representatives of stronger research fields including generic political science research and business studies including organization and management research and accounting research. In these circumstances it is advisable to choose empirical topics of research that have not been too appropriated by political science, such as the study of the politicization of executive agencies has been (Bertelli and Grose 2011), or by business research, as has been the case with the study of the ideologies of government accounting and budgeting reforms (Hyndman et al. 2013, despite these author's partial reliance upon Pollitt and Bouckaert 2011). Adopting, modifying and utilizing approaches previously used in other fields of research is central to the strategy of this article.

A third non-epistemological reason behind this article concerns the specificity of government budgeting. Its characteristics give it institutional, cognitive and intellectual autonomy in comparison with certain other domains of government and public administration, such as general and personnel management, organization development, or information systems research. Moreover, harmonization of government budgetary institutions, procedures and techniques has been pursued for long by such organizations as the OECD or IMF (see, for instance, OECD 2005; Wanna, Jensen, and de Vries 2010; Pal 2012; IMF 2013a), and the European Union actively promotes similar developments in the member states and the EU partner countries. However, the remarkable harmonization of government budgeting has not meant that it is homogeneous in all countries (Lienert 2013), as high degrees of *formal compliance* may fail to guarantee *actual convergence* in institutionalization (Ashworth, Boyne, and Delbridge, 2009; Goldfinch and Wallis 2010).

## Hypotheses

Bayesian-inspired research rejects testing if null hypotheses can be rejected in favor of the hypotheses that the researcher has proposed. Bayesian-inspired research may certainly propose hypotheses provided that these articulate the researcher's expectations about probabilities that posterior evidence may ultimately indicate.

As mentioned above, long-term harmonization has been advancing in government budgeting and budgetary legislation, but despite progressing formal compliance, actual institutional convergence may not have been achieved. A first hypothesis can be proposed:

H1: We will find characteristics of polarization if we compare budgetary legislation passed in different established Western democracies.

The prior expectation that important differences obtain between developed Western democracies in their budgetary legislation calls for the examination of possible reasons for these differences. Although interesting and important research is available on what has been called "budgetary governance," such research comprises empirical generalizations (Hallerberg et al. 2007) or informative, well-executed country studies (Raudla 2010) rather than approaches to systemic and structural differences between institutions and with keen acknowledgment of historical institutional traditions. This article builds upon the prior expectation that legal system traditions (Zweigert and Kötz 1998; Pargendler 2012; Table 1, columns 6 and 7) continue to comprise contextual influences upon national differences in government budgeting as represented in budgetary legislation. Four hypotheses can be proposed:

H2: We will find differences between established Western democracies in their budgetary legislation along dividing lines between legal system traditions.

H3: We will find a dividing line among established Western democracies in their budgetary legislation between countries with common law traditions and those with civil law traditions.

H4: We will find further dividing lines between established Western democracies in their budgetary legislation depending on their subscription to civil law traditions of the German, Napoleonic or Nordic subtypes.

H5: We will find that countries representing the Napoleonic subtype of civil law traditions differ more in their budgetary legislation from countries with common law traditions than do countries with civil law traditions representing the German or Nordic subtypes.

We can acknowledge the longer-term harmonization of government budgeting and budgetary legislation since the 1940s with explicit hypotheses. Assuming accelerated trends of harmonization (see Wanna, Jensen, and de Vries 2010; IMF 2013a), the following hypotheses can be proposed:

H6: We will find that national budgetary legislation ages rapidly, during time spans as short as twenty years.

H7: Acknowledging that countries with common law traditions have comprised frequent global models in budgetary reforms (Wanna, Jensen and De Vries 2010), we will find that civil law countries with outdated government budgetary legislation differ more from the common law countries than other countries of the same or a nearby subtype of civil law traditions.

H8: At one extreme end of the characteristics of government budgetary legislation, we will find common law countries with newer or constantly updated budgetary legislation rather than any country representing the same traditions but retaining older elements in its budgetary legislation.

Many published topic modeling studies have been exploratory, which comprises part and parcel of what many dedicated computational methods scholars indicate what they are doing, but confirmatory topic modeling can also be envisaged. This justifies hypotheses about what topics will be discerned, which topics the documents examined (and the respective countries) will represent, and what interpretations the examination suggest as concerns the contents of these topics. Two further hypotheses can be proposed on the subsidiary assumption that if more than two topics are estimated, their interpretation will have to be exploratory and inferential rather than confirmatory:

H9: We will find a topic representing the heritage of the common law system in budgetary legislation.

H10: We will find a topic representing the heritage of the Napoleonic subtype of the civil law system in budgetary legislation.

## RESEARCH METHODS

The corpus of the thirteen texts was pruned by means of the text mining library tm (Feinerer 2013) of the statistical library system R. The tm library was used to turn all capital letters into small type, abolish numbers, punctuation marks and stopwords (e.g., articles, particles, conjunctives, pronouns, and forms of such words as to "be" and to "have"), and, in this examination, to eliminate all words

that were present in only one or two of the thirteen texts of the corpus. The eliminations left 2,992 of the original 5,351 words. The tm program enables the stemming of words, but stemming was withheld on the expectation that it would lead to serious semantic loss. Applying more fine-tuned pruning methods, such as those enabling so-called lemmatization and separating properly substantive, adjectives, pronouns and verbs from each other was left a task of other studies.

**Unsupervised Latent Trait Scaling**

The genealogy of the methods applied in this article starts with the 18th-century work of Rev. *Thomas Bayes*, those who later made his work public, and *Pierre-Simon, Marquise de Laplace*, who independently invented aspects of Bayesian statistics and extended them. The genealogy also comprises work on statistical distributions by *Siméon Denis Poisson* in the early 19th century and by others, and early practical applications which examined the Poissonian "law of small numbers" by such authors as the Polish-German scholar *Ladislaus v. Bortkiewicz*, who at the end of the 19th century (in a seminal study on casualities in German cavalry) effectively demonstrated that events with low frequency among a mass of events indeed follow the Poisson distribution. Within political science research, both supervised and unsupervised latent trait scaling (Laver, Benoit and Garry 2002; Proksch and Slapin 2008) continue earlier political science work that utilizes data coded manually by single or several coders in preparation for studies on latent polarized traits, such as studies on political attitudes that defy analysis by means of more straightforward approaches. The more recent research was preceded by decades of political studies examining the revelation of preferences in such contexts as those of roll-call voting (Lindstädt et al. 2011). However, to date, computerized data acquisition has not crowded out manual procedures in political science (Lowe and Benoit 2013) or elsewhere (for a study on a theme close to this article, see Hyndman et. al. 2013).

In this article, unsupervised latent trait scaling was carried out by means of the R-Wordfish program (Proksch and Slapin 2009). This program supports the examination of word frequencies in texts, and assumes the Bayesian prior that a Poisson process generates these frequencies. This makes Wordfish one of the approaches of "strong" Bayesian analysis, alternatively called naïve Bayesianism, building on assumptions that the presence or absence of a particular characteristics is unrelated to the presence or absence of any other relevant characteristic. Wordfish has not generally performed worse than alternative techniques of scaling, such as the supervised latent trait scaling algorithm called Wordscores (Lowe and Benoit, 2013). The Wordfish assumption on the Poisson distribution for the word frequencies promotes simplicity, as this distribution has only one parameter, $\lambda$, which comprises both the mean and the variance. In brief, Wordfish builds upon the assumption that the number of times that a word, j, is present in a document derives from a Poisson distribution. The general form of the Wordfish model is:

$$y_{ij} \sim \text{Poisson}(\lambda_{ij}) \quad (2)$$

$$\lambda_{ij} = \exp(\alpha_i + \psi_j + \beta_j \times \omega_i) \quad (3)$$

In (1), $y_{ij}$ is the count of word j in document i, and in (2), $\alpha$ is the set of fixed effects related to a document, $\psi$ is the set of fixed effects related to words, $\beta$ is the set of estimates of word-specific weights to capture the importance of each individual word in discriminating between positions that the texts represent, and $\omega$ is the set of estimates for the position that each document represents. Both types of fixed effects, $\alpha$ and $\psi_j$, are of lesser interest, as they only control for the possibility that all documents include some words rather than others, and that some documents include more text and therefore more words than other documents. In unsupervised scaling the interest lies primarily in estimating the $\omega$'s, indicating the positions taken in the documents, and the $\beta$'s, indicating the

words that differentiate between these positions. In this article, Wordfish was acquired from the particular source of the R-Austin library, in which the "bugs" of the original Wordfish program have been fixed (Lowe 2011).

The technicalities of the Wordfish estimation are explained in the Wordfish manual (Proksch and Slapin 2009). The right-hand side of equation (3) is estimated by means of an expectation maximization algorithm, which defines an iterative procedure to compute maximum likelihood estimates for the latent variables, from $\alpha$ to $\omega$. The estimation consists of five steps. First, starting values for $\alpha$, $\psi$, $\beta$ and $\omega$ are obtained. Second, the document parameters $\omega$ and $\alpha$ are estimated conditional on the expectation for the word parameters $\psi$ and $\beta$ by maximizing a log-likelihood function related to each of the documents. Third, the word parameters $\psi$ and $\beta$ are estimated conditional on the expectation of the document parameters $\omega$ and $\alpha$, obtained in step 2. For each word, a log-likelihood function is maximized. Fourth, the log-likelihood of the overall model is calculated as the sum of the individual word log-likelihoods obtained at step 3. Fifth, steps 2–4 are repeated until, hopefully, convergence is obtained. The Wordfish program enables the calculation of credibility intervals for the scaling estimates using a parametric bootstrap. The standard number of 500 iterations characteristically requires some computer calculation time with better-performing personal computers, such as twelve hours as in this study.

## Topic Modeling

Known since classical Antiquity, topics comprise elements that language users invent or innovatively transfer from other uses to those of their own in order to influence the cognitions, emotions and perceptions about these language users' ethos held by their audience including their opponents. Bayesian-inspired "topic modeling," hardly bearing more than an indirect relationship with the historical antecedents indicated and therefore representing "vulgar" rather than true

humanism, supports the interpretation of latent meaning structures in corpuses comprised of texts. The probabilistic topical model called the latent Dirichlet allocation (abbreviated as LDA, see Blei et al. 2003), paying tribute to the German 19th-century mathematician *Johann Peter Gustav Lejeune Dirichlet*, has also found applications in fields reasonably close to public administration research (Clark and Lauderdale 2013; DiMaggio, Nag, and Blei 2013; Levy and Franklin 2013).

LDA is used to analyze unobservable latent factors in order to clarify interesting similarities that obtain the material examined. LDA not only enables the examination of separate words but also the investigation of co-occurrences of words. In LDA, documents are understood to comprise mixtures of a certain number of topics that regulate the probability of words finding their way into these documents. LDA assumes that the distribution of the topics examined has a Dirichlet prior. While applying LDA, the topics and their probability distribution in the documents examined are understood to comprise hidden random variables, which are built into a hierarchical probabilistic model, and estimated by means of approximating the conditional distribution of these variables in the corpus of documents examined. This is done by means of sampling-based algorithms, such as Gibbs sampling constructing a Markov chain Monte Carlo algorithm (abbreviated as MCMC, see Blei 2011). Topic modeling has often been used in exploratory ways. Inferential procedures with manual labeling of the topics are common, although computer-assisted labeling has also been elaborated (Grimmer 2010). However, as indicated above, confirmatory topic modeling testing theoretically grounded hypotheses explicitly proposed is not ruled out, either.

In this article, the same corpus topic of text documents, first pruned by means of text mining, is examined not only with latent trait scaling but also with topic modeling. The topic modeling was carried out by means of the R-topicmodel library (Grün and Hornik 2013a, 2013b). First, the probability distribution of words, $\beta$, has to be determined for each topic, assuming a Dirichlet prior, $\delta$:

$$\beta \sim \text{Dirichlet}\ (\delta) \tag{4}$$

Second, the proportions of the topic distribution, θ, for each w, document, have to be determined, also assuming a Dirichlet prior, α:

$$\theta \sim \text{Dirichlet}\ (\alpha) \tag{5}$$

Third, for $w_i$, each of the N words, there shall be the choice of a topic, $z_i$, on the assumption of the multinomial prior distribution of this topic:

$$z_i \sim \text{Multinomial}\ (\theta) \tag{6.1}$$

Fourth, $w_i$, each of the N words, shall be chosen on the assumption of a multinomial prior distribution of each word conditioned on the topic:

$$z_i\text{: } p(w_i|z_i, \beta) \tag{6.2}$$

After the four steps, the log-likelihood of the entire research material, calculated as the sum over the log-likelihoods of all documents in the corpus examined, is maximized with respect to the model parameters α and β. The R-topicmodel library presupposes that k, the number of topics, is fixed a priori. The model is first fitted using the LDA library function "LDA," including possible further specifications—all made in the analysis reported in this article—such as giving an initial value to the Dirichlet prior α, defining the number of iterations to reach stable posterior estimates, and introducing a "seed word" to start the estimation in order to enable the reproducibility of the results (Grün and Hornik 2013a, 2013b). Next, an LDA function named "posterior" is used to obtain the

distribution of words on each topic and the distribution of topics in each document. LDA also allows for first dividing the text corpus examined into a "training data set" and a "text data set," and next making the program learn to estimate the model, though this option was not used in this analysis. The Bayesian testing resources offered by the R-topicmodel library are rather limited, the indicator called "perplexity" that this library offers is not particularly informative, and to estimate, for instance, the more useful test criterion DIC (deviance information criterion), some other topic modeling library such as R-lda should be used (Mimno and Blei 2011).

## RESEARCH MATERIAL

The research material was comprised of federal or national government budgetary legislation in thirteen countries: Australia, Austria, Canada, Estonia, Finland, France, Iceland, Italy, the Netherlands, New Zealand, Sweden, Spain, and the United Kingdom (Table 1). The data are from the year 2013 or the latest earlier available year before 2013, which means that later comprehensive or partial reforms of budgetary legislation have not been taken into account. For instance, the new Estonian Budget Act is being put into force in steps since 2014, and since 2015 Iceland has a new Organic Budget Act (Estonia 2016; IMF 2016).

Some countries had to be excluded from the analysis because of their unique characteristics, such as the United States with its very elaborate legislative budgetary process and the other structurally complex federal countries of Germany, Switzerland, and Belgium. Some countries could not be included because of the absence of legal norms on government budgeting, such as Denmark and Norway, which had only passed administrative regulations on this issue by the year 2013 (OECD 2005; Ernst & Young 2012).

It is an asset in the present analysis that the thirteen countries examined comprise a group that is in many, but not too many, aspects reasonably homogeneous, such as highly developed Western

democracies in Europe or with European origins (Table 1). The research material mostly derives from a website delivering original English legal texts on government budgeting or translations into English (World Bank 2013). The Austrian legal text derives from a governmental website (Austria 2013), and the Italian legal text originates from an official law database (Italy 2013). All texts used were available either in the original English or in English translation, except for the Italian text. After a first rough automatic translation (Babylon 2013), with good reading comprehension of the Italian language, I translated myself the Italian text into English. All texts available in the World Bank website were replaced with newer text versions if available in other sources. Applying common practices of automatic text analysis for two countries, the UK and Finland, two separate legal texts were merged into a single text to attain better representativeness of the documentation on these countries.

## UNSUPERVISED LATENT TRAIT ANALYSIS OF BUDGETARY LEGISLATION IN THIRTEEN COUNTRIES

The unsupervised latent trait analysis of budgetary legislation in the thirteen countries examined gives posterior support for the prior expectations formulated in the hypotheses proposed. As indicated above, the α (alpha) fixed effects, related to documents and the countries behind these documents, are of little interest for the model interpretation, and therefore give no more than visual support for the display of the positions taken in the documents, ω (omega) (Figure 1).

FIGURE 1 ABOUT HERE

As proposed in the hypotheses, differences obtain between the countries examined (H1), legal system traditions play a role in these differences (H2), and countries with common law traditions differ from countries with civil law traditions (H3). Spain, Italy and France, each representing

Napoleonic civil law traditions, along with Estonia representing the German subtype of the civil law tradition rather than any other subtype, are situated at one extreme end of the ω values, and at the other extreme end we find three overseas representatives of the common law tradition, Australia, Canada and New Zealand (H4, H5). The three Nordic countries included in the analysis, Finland, Iceland and Sweden, receive similar ω values each, although they do not form a clear-cut group, as Austria in the German subtype of the civil law tradition receives a comparable ω value (H4). Both Estonia, and less extremely Iceland, represent outdated government budgeting (H6, H7), which revealed by the fact that both countries have been engaged since the early 2010s in comprehensive reforms of their budgetary legislation (see the explanations section in Table 1). The Netherlands, with hybrid Napoleonic-German characteristics in its civil law system, comprises a somewhat anomalous case according to the estimation results. Last, we find Australia, Canada, New Zealand and the United Kingdom about where hypothesis H8 proposes.

According to the posterior probabilities of the estimated model of unsupervised latent trait scaling, certain countries are similar enough to receive credibility intervals of their ω values—indicating the positions of the documents that represent these countries—that overlap between the credibility intervals of the values received by certain other countries (Table 2). In this respect Australia and New Zealand hardly differ from each other, nor do Austria, Finland and Iceland, or Estonia and Spain. The other countries are more unique, from Canada at the extreme positive end of the ω values to and Italy at the extreme negative end, and, between these extreme ends, France closer to the negative end and the Netherlands, Sweden and the United Kingdom in the middle ranges of the ω values.

TABLE 2 ABOUT HERE

The expectation in unsupervised latent trait scaling is that frequent words do not discriminate between the documents examined, as these words do not distinguish important properties from each other (Proksch and Slapin 2008, 2009). Such words should have large fixed effects (θ) associated with word weights (β) close to zero, whereas words with discriminating capacity should be infrequent and have small fixed effects. The characteristic scatterplot "pyramid" of unsupervised latent trait scaling (Figure 2) illustrates that the examination delivers what it should. Such words as the verb form "shall" and the nouns "government" and "budget," all of which we expect to be frequent in any budgetary legislation, have next to zero word (β) weights (Table 2).

FIGURE 2 ABOUT HERE

Words that best discriminate between the documents examined are situated at both ends of extreme β values. Somewhat more such words and with more extreme absolute values are situated in the lower left part of Figure 2 on the one hand, but on the other the mass of words is concentrated more on the positive side. For further illustration, let us examine the ten words with the highest positive β values and the ten words with the highest negative β values. Note that only some of these words are visible in Figure 2. From among the words with the highest positive β values we find the word "subsidiary" both in the plural and the singular, and the words "governor," "corporations," and "majesty". Among the words with the highest negative β values, we detect such words as "administrations," "chambers," "programming," "competence," and "quantification." The differences between these two sets of words suggest inherited differences between the institutionalized legal systems within which each of these sets are embedded.

Certain words from among those with the highest positive β values emphasize the overseas heritage of the common law system, found among the countries examined in Canada, Australia and New Zealand, each literally (see Table 2 and the above text) indicating Britain's "majesty" as the

head of state who is represented by a resident "governor." Moreover, we may argue that the vocabulary of budgetary legislation in these countries represents governance by means of what is known by the term "whole-of-government" (Christensen and Lægreid· 2007), indicated by reference to "subsidiary" organizations of government and public sector organizations instituted as "corporations." Notably, in recent decades these three countries have turned to common global models for budgetary reforms carried out in other countries (Wanna, Jensen and De Vries 2010).

To single out what the words with the highest negative β values represent, we can utilize contrasts between this word set and the set with the highest positive β values. While in the former set, governance with such institutional supports as the "majesty" and the "governor" receives accents, in the latter set the challenges of pushing the proposed government budget through both "chambers" of the legislature are emphasized. Other words with the highest negative β values take up different aspects of the institutionalization of governance than certain words in the set with the highest positive β values. Words in the former set express concerns with the distribution of "competence," the roles of various "administrations" in the budgetary process, and procedures of "planning" and "quantification," whereas structural and institutional concerns of governance come up in the word set with the highest positive β values, including the words "subsidiaries" and "corporations."

Credibility intervals were not calculated only for the posterior document estimates by means of parametric bootstrap, but also for each word included in the analysis. However, the reporting conventions of unsupervised latent trait analysis certainly do not require the inclusion of these results for the 2,992 words left in the examination after the initial pruning.

## TOPIC MODELING OF BUDGETARY LEGISLATION IN THIRTEEN COUNTRIES

The restricted number of documents and countries, thirteen, effectively precluded the estimation of more than three topics. A "seed word" was selected at random at the start of the estimation, 0.1 was used as the prior for the parameter α, and 1,000 iterations were run to estimate the model. Following common topic modeling practice, the $\alpha = 0.1$ struck a balance between the concentration of the posterior probabilities of the topics within the documents examined either upon only one topic (with high α values) or many or all topics (with low α values). The same model with the same seed word was run three times to ensure that the results were stable enough. At most, what changed from estimation to estimation comprised the order of the topics, not their contents. The reason why the results of each estimation are not exactly the same comprises the Markov chain Monte Carlo (MCMC) algorithm built into the latent Dirichlet allocation topic modeling applied in the analysis. As indicated in the methods section, because of the limited resources offered by the R-topicmodel library, comprehensive testing of the final model was not carried out. This omission has commonly been accepted in previous refereed research utilizing topic modeling.

The posterior probability distributions resulting from the topic modeling (Table 3; Table 4) support hypothesis 9, taking up a topic that can be named the "Heritage of the common law legal system," and hypothesis 10, taking up a topic that can be called the "Heritage of the Napoleonic subtype of the civil law legal system." The third topic can be inferentially labeled the "Heritage of the Nordic and German subtypes of the civil law legal system." As is the rule in topic models, many words appear in two or all three topics. Some of the words with the highest probability of inclusion in any of the three topics hardly more than indicate that the corpus examined indeed comprises legal texts (such as the word "law," and the modal verbs "must," "shall," and "may") or includes references or cross-references to the specific parts of the legal text in question (such as "section," "article," and "paragraph").

Let us look for words of more substance that are characteristic of certain topics rather than others. Words that deal with the *contents* of budgeting are most frequent in the first, "German and

Nordic" topic: "budget," "finance," "financial," "expenditure" (both in the singular and the plural), "appropriations," "cash," "assets," and "provisions." In the second, "common law" topic we find a good many words that characterize the *institutionalization* of budgetary governance with special reference to the key actors of this institutionalization: "minister," "crown," "treasury," "board," "parliament," "council," and "governor." Words characterizing *accountability* are more frequently found in the third, "Napoleonic" topic than in the others: "account," "accounting," "report," "auditing," and "information." It would be interesting to find correspondences between these emphases and those in research on budgetary governance (Hallerberg et al. 2007) and in research on ideologies of government budgeting and accounting (Hyndman et al. 2013). However, it derives from the very different purposes, objectives, research materials and procedures of these two studies and this article that meaningful examination of such correspondences is not possible.

TABLE 3 ABOUT HERE

TABLE 4 ABOUT HERE

As proposed in hypothesis 9, the countries in which only the second topic is present according to the posterior probabilities estimated comprise Canada, New Zealand and Australia. The probability of the second topic in the two combined documents representing the United Kingdom is not low, either, but exceeds one half of the total. As proposed in hypothesis 10, the countries in which the third topic has the highest posterior probability include two inheritors of Napoleonic civil law, Spain and Italy. In the documents from these countries only the third topic is present according to the estimation results. The estimation presents the host country of the Napoleonic tradition, France, as a hybrid between this topic and the German-Nordic topic, which is in accordance with the commonly acknowledged Germanic traits in parts of the French legal heritage. Estonia stands out as

something of an anomaly; despite the predominantly German heritage of its legal system, over two-thirds of the vocabulary examined represent the third or "Napoleonic" topic in the Estonian document. It should be separately examined, if the Estonian uniqueness might derive from possiboe French influences upon this country's budgetary legislation of 1938 and again once the act examined was passed after the restoration of Estonian independence although soon heavily amended (Raudla 2010). In the Austrian document only the first topic is present. This topic also has a high posterior probability in the Swedish and the Finnish documents, and a fairly high posterior probability, or almost two-thirds, in the Icelandic document.

In the documents from the thirteen countries, the posterior probability of finding only one topic is one hundred per cent in five countries (Australia, Austria, Canada, Italy, New Zealand, and Spain) and almost 95 per cent in two other countries (Finland and Sweden). The posterior probabilities for four countries are divided between a dominant and a minor topic (Estonia, France, and Iceland), and in two countries between a dominant topic and two minor topics (the United Kingdom, and to a lesser extent the Netherlands).

## CONCLUSIONS AND DISCUSSION

The purpose of this article has been a Bayesian-inspired examination of a resilient theme of public administration in its financial aspect, meaning government budgeting. This examination was carried out with the support of two methodological research objectives, the first indicating the utilization of unsupervised latent trait scaling, and the second the utilization of topic modeling. This article has not aimed to add to the methods it applies, but to expand the scope of their applications, suggest a certain combination of their utilization, and implement this combination in empirical research. Arguably, the research objectives have been reasonably achieved, and the research purpose has been appropriately pursued.

The eight hypotheses proposed received support once posterior probabilities were estimated by means of unsupervised latent trait scaling, and two hypotheses were supported once estimation by means of topic modeling had been carried out. According to the estimated posterior probabilities, remarkable differences obtain between the countries examined along dividing lines between legal system traditions. The unsupervised latent trait scaling indicated a cleavage in budgetary legislation between overseas inheritor countries representing common law traditions, Australia, Canada and New Zealand, and countries with civil law traditions representing the Napoleonic subtype, or especially Spain and Italy. The other countries examined occupy the middle ground between the two extremes. The topic modeling indicated the posterior probability of a topic of the heritage of the British common law system and a topic of the heritage of the Napoleonic subtype of the civil law legal system. Moreover, on an exploratory basis a third topic was labeled the "Heritage of the Nordic and German subtypes of the civil law legal system."

While the posterior probabilities estimated indicated some countries, represented by the documents examined, as if "ideal types" representing one topic only, other countries rather were hybrids. The legislation that the second, "common law" topic catches accentuates institutional governance aspects of government budgeting, whereas the third, "Napoleonic" topic emphasizes budgetary accountability, and the first, "German and Nordic," characteristically takes up the contents of budgeting. These results agree by and large with Lienert's (2013) conclusions on resilient inter-country differences in budgetary legislation in different countries.

Arguably, the foremost contribution of this article has been to elaborate extensions of Bayesian-inspired public administration research utilizing texts as the research material and applying certain present-day digital methods of examination. Figure 3 gives a visual summary of the analysis with special reference to its topic modeling part. The Bayesian prior of the study was comprised of the first preliminary expectations concerning the latent elements depicted, and the examination

advanced via assumptions of likelihood to estimates of the posterior probabilities that finally link the manifest and latent elements of the analysis.

INSERT FIGURE 3 ABOUT HERE

Analogous results to this study might have certainly been achieved by means of frequentist statistical research methods of classificatory and categorical analysis. However, according to the very purposes of this article, it has examined what Bayesian-inspired approaches may deliver. The empirical results of the article can be seen as a somewhat more minor achievement. After all, the utility of assuming the resilience of divisions between legal traditions has been questioned, and in some research fields such assumptions have been seen as downright counterproductive (Pargendler 2012; Lindahl and Schadewitz 2013; however, in public administration research, see Painter and Peters 2010). In any event, in this article the hypotheses proposed did ground the estimation of posterior probabilities on the resilience of the divisions indicated despite advancing global harmonization of government budgeting ever since the 1940s (Wanna, Jensen and de Vries 2010).

More generally, this article joins other studies that take into account the context of public administration to help explain why the same influences may not bring about the very same results let alone do so soon all over the world (Ashworth et al. 2009; Goldfinch and Wallis 2010; O'Toole and Meier 2013; Pollitt 2013). In the article, the context was comprised of the historically mediated institutional heritage of different legal systems and their subtypes, and, *mutatis mutandis*, traditions of different public administration systems. Reference to the importance of context was used in this article in Bayesian-inspired ways to make it intelligible why decades of harmonization of government budgeting have not eradicated heterogeneity despite the reasonable overall homogeneity of the set of Western countries examined.

The limitations of the research approach and the research methods applied in this article require concluding comments. Unsupervised latent trait scaling and topic modeling are "bag of words approaches", in which the "bag" is comprised of a multiset (a set whose members may be included in this set more than once) of the words present in a text without regard to grammar and word order (Blei, Ng and Jordan 2003). The bag of words approaches have been generally seen as fitting for document classification, but hardly well suitable for the sophisticated interpretation of meanings and contents. Certainly, no algorithm has any understanding of even the first meaning and content! However, the Bayesian-inspired methods have performed reasonably well in this article. Arguably, the examination of research material made up of texts is too interesting and important to be left only to the domain of "frequentist" quantitative research such as extensions of traditional content analysis, or qualitative research that builds upon extreme philosophical constructivism or identifies itself with the attribute "post" preceding some such term as "modern." Moreover, the methods applied in this article, other Bayesian-inspired methods and other methods can be used to cross-check the results obtained by any other from among these methods (Grimmer and Stewart 2013; Lowe and Benoit 2013), promising if not constant improvement by means of mutual methodological learning, at least methodological dialogue.

The empirical study reported in this article has been carried out under certain delimitations introduced by the investigator. For two reasons this study has comprised cross-sectional studies (Levy and Franklin 2013; Gill and Witko 2013) without joining the expanding time-series research that utilizes texts as its research material (Proksch and Slapin 2008; Grimmer 2010; Bertelli and Grose 2011; Clark and Lauderdale 2010; DiMaggio, Nag and Blei 2013). This cross-sectional character has arisen from a combination of the author's interest in international comparative study of public administration in its financial and budgeting aspects on the one hand, and on the other the difficulties to prepare a corpus comprised of consecutive texts of budgetary legislation passed in numerous countries over a longer time period. Arguably, the reasonably good availability of the

texts examined in this article comprised a fortunate "opportunity window" enabling this study to evolve in the first place.

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**Table 1**

Characteristics of Countries and Texts Examined

| 1 Country | 2 Population, million | 3 GDP PC PPP USD | 4 Government, % GDP | 5 Membership | 6 Longer-term legal traditions | 7 Shorter-term legal traditions | 8 Titles of legal texts examined, in English | 9 Latest upgrade | 10 Words in English |
|---|---|---|---|---|---|---|---|---|---|
| Australia | 23.3 | 43,661 | 35.3 | BC | Common law | British | Financial Management and Accountability Act 1997 | 2013 | 12,503 |
| Austria | 8.4 | 43,322 | 50.9 | EU, euro | German | German | Federal Organic Budget Act 2013 | 2013 | 40,151 |
| Canada | 35.2 | 42,303 | 41.6 | BC | Common law | British | Financial Administration Act 1985 | 2013 | 37,994 |
| Estonia | 1.2 | 22,268 | 43.0 | EU, euro | German | German | Law on State Budget | 1999 | 4,659 |
| Finland | 5.5 | 38,395 | 54.7 | EU, euro | Nordic | Nordic | 1988 Budget Act, 1992 Budget Decree (single text file) | 2007 | 21,494 |
| France | 66.0 | 35,961 | 56.1 | EU, euro | Roman, German | Napoleonic | The Organic Law on Budget Laws 2001 | NA | 8,946 |
| Iceland | 0.3 | 40,523 | 43.7 | None | Nordic | Nordic | The Government Financial Reporting Act 1997 | NA | 4,690 |
| Italy | 59.7 | 30,170 | 50.6 | EU, euro | Roman | Napoleonic | Law of Accounting and Public Finance 2010 | 2013 | 23,306 |
| Netherlands | 16.8 | 42,942 | 49.9 | EU, euro | Roman, German | Napoleonic, German | Government Accounts Act 2001 | 2005 | 15,332 |
| New Zealand | 4.5 | 30,695 | 32.8 | BC | Common law | British | Public Finance Act 1989 | 2013 | 47,378 |
| Spain | 46.7 | 30,253 | 42.1 | EU, euro | Roman | Napoleonic | General Budgetary Law 2001 | NA | 43,711 |
| Sweden | 9.6 | 42,973 | 49.2 | EU | Nordic | Nordic | Budget Act 2011 | 2011 | 4,290 |
| United Kingdom | 63.2 | 37,384 | 44.4 | EU, BC | Common law | British | Exchequer and Audit Departments Act 1866, Charter of Budget Responsibility 2011 (single text file) | 2013 | 3,847 |

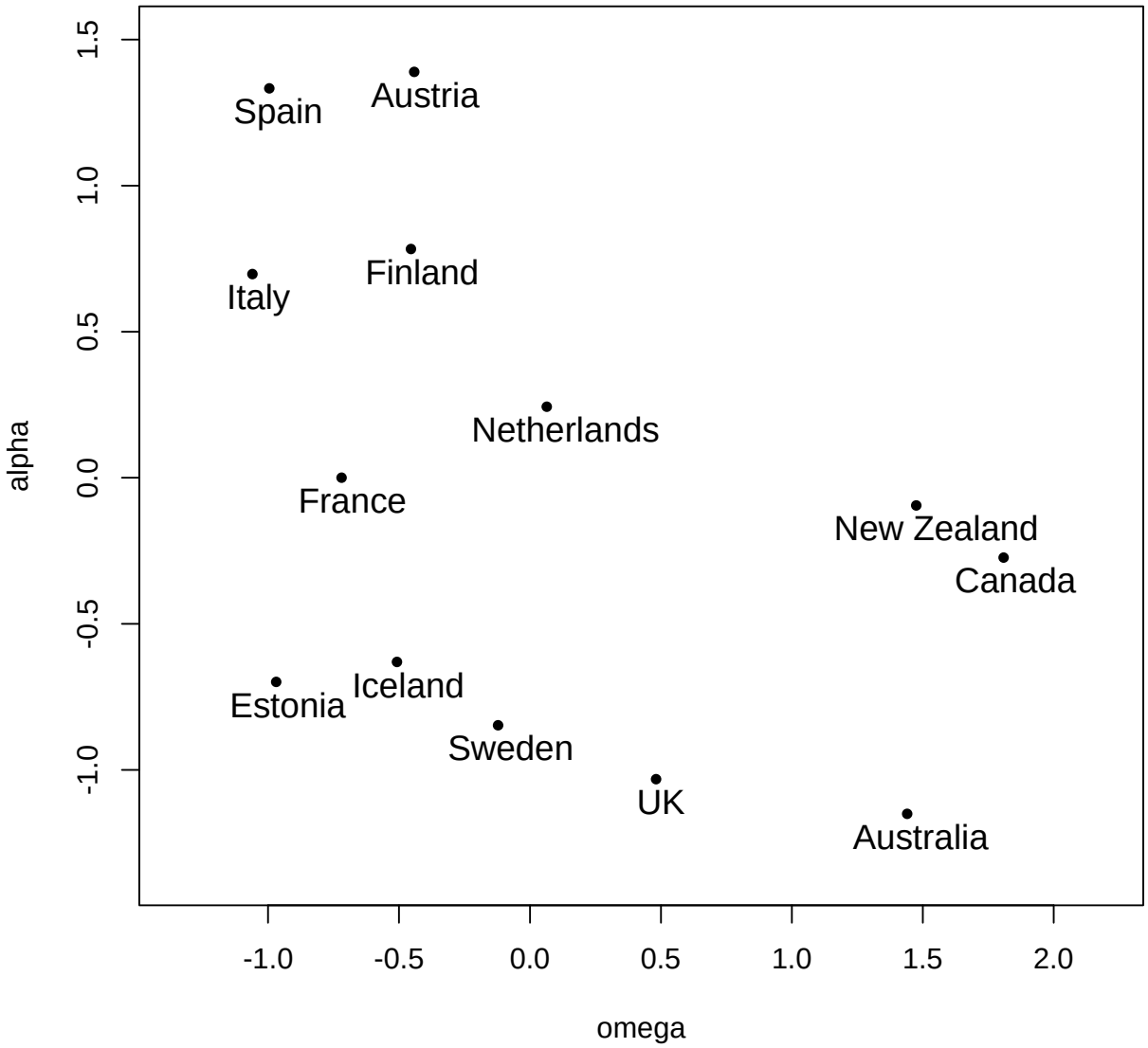
*Explanations:* Austria, Australia and Canada are federal states and the other countries are unitary states, but Italy and Spain have regions with strong autonomy, and Scotland has been contemplating independence from the United Kingdom. The United Kingdom and Canada apply, and until recently New Zealand applied, a first past the post electoral system resulting in few effective political parties, whereas the other countries apply various versions of the proportional electoral system. All countries have a multi-party parliamentary government, which France supplements with semi-presidential characteristics.

Column 3 gives the country's gross domestic product (GDP) per capita in purchasing power parity terms in US dollars, and column 4 the GDP share of the item general government, comprising by and large the entire public sector including the social security funds (IMF 2013b). Both figures were estimates for 2013 at the time of their publication. Column 5 indicates if a country is an EU member state and a member of the EU legal system, a member of the EU euro area including the European Central Bank system, or a member of the British Commonwealth (BC). Columns 6 and 7 ignore some of the finer grain, such as the civil law heritage in the Canadian province of Quebec, the specificity of the legal heritage of Scotland, and the unique characteristics of Spanish law. Column 9 gives the year of the latest upgrade of the legislation examined available in this article, and column 10 gives the number of words in the legislation examined before editing carried out for the present analysis.

According to public domain information, Estonia should have passed a new Law on State Budget that should have come into effect on 1 January, 2014. However, this had not happened by that date. According to other public domain sources, Iceland has also been preparing a new organic budget act, but the older act was retained in the research material also in this case.

**Figure 1**

Position Estimates of Budgetary Legislation in Thirteen Countries




*Explanations:* The x-axis indicates the Wordfish latent trait scaling estimates for each document's (and country's) position, ω (omega), and the y-axis indicates the fixed effects related to each document (and country), α (alpha).

**Table 2**

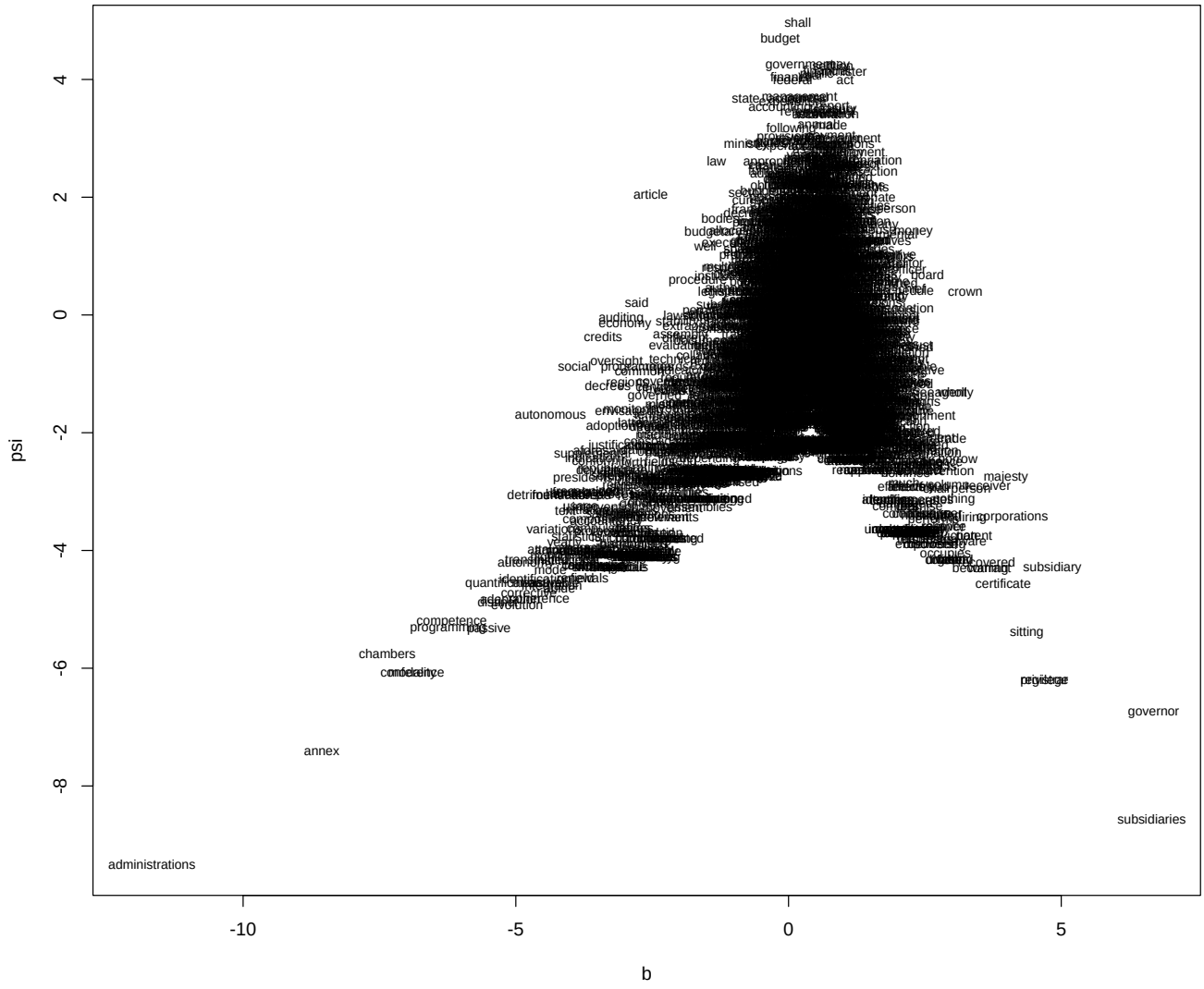
Test Results by Countries on the Documents Examined

| Countries | Indicator of position taken in documents from the country, ω | 95% lower credibility interval of ω | 95% upper credibility interval of ω |
|---|---|---|---|
| Australia | 1.4401 | 1.4002 | 1.4600 |
| Austria | -0.4418 | -0.4493 | -0.4043 |
| Canada | 1.8086 | 1.7689 | 1.8227 |
| Estonia | -0.9689 | -1.0135 | -0.9469 |
| Finland | -0.4544 | -0.4684 | -0.4097 |
| France | -0.7192 | -0.7476 | -0.6848 |
| Iceland | -0.5077 | -0.5420 | -0.4436 |
| Italy | -1.0599 | -1.1131 | -1.0666 |
| Netherlands | 0.0644 | 0.0412 | 0.1218 |
| New Zealand | 1.4748 | 1.4423 | 1.4895 |
| Sweden | -0.1680 | -0.0422 | -0.1220 |
| Spain | -0.9953 | -1.0317 | -0.9922 |
| United Kingdom | 0.4814 | 0.4300 | 0.5579 |

*Explanations:* We may put a note on Italy's ω value situating itself outside the confidence intervals calculated for this country by means of parametric bootstrapping. Possibly, with the number of iterations substantially exceeding the standard number of 500 iterations carried out, Italy's credibility intervals would have adjusted themselves to include Italy's ω between their two extreme values.

**Figure 2**

Word Weights and Word Fixed Effects in Budgetary Legislation of Thirteen Countries




*Explanations:* The x-axis indicates the word weight values β (beta) (despite the letter b that the program default inserts and does not allow to correct), and the y-axis indicates the word fixed effects ψ (psi).

**Table 3**

A Three-Topic Model of Budgetary Legislation in Thirteen Countries

| Descending probability order of words to belong to a topic | Topic 1, Heritage of the Nordic and German subtypes of the civil law legal system | Topic 2, Heritage of the common law legal system | Topic 3, Heritage of the Napoleonic subtype of the civil law legal system |
|---|---|---|---|
| 1 | "shall" | "minister" | "article" |
| 2 | "budget" | "may" | "state" |
| 3 | "government" | "crown" | "shall" |
| 4 | "federal" | "act" | "budget" |
| 5 | "section" | "corporation" | "public" |
| 6 | "finance" | "section" | "law" |
| 7 | "management" | "financial" | "general" |
| 8 | "act" | "public" | "finance" |
| 9 | "minister" | "must" | "year" |
| 10 | "year" | "money" | "accounts" |
| 11 | "accounting" | "person" | "expenditure" |
| 12 | "may" | "treasury" | "may" |
| 13 | "financial" | "report" | "financial" |
| 14 | "statement" | "shall" | "paragraph" |
| 15 | "accounts" | "department" | "entities" |
| 16 | "ministry" | "appropriation" | "referred" |
| 17 | "expenditures" | "year" | "accounting" |
| 18 | "expenditure" | "board" | "ministry" |
| 19 | "fiscal" | "parliament" | "following" |
| 20 | "state" | "subsection" | "treasury" |
| 21 | "audit" | "council" | "provisions" |
| 22 | "central" | "fiscal" | "revenue" |
| 23 | "referred" | "information" | "said" |
| 24 | "cash" | "respect" | "provided" |
| 25 | "information" | "regulations" | "credits" |
| 26 | "account" | "amount" | "auditing" |
| 27 | "assets" | "governor" | "account" |
| 28 | "line" | "means" | "report" |
| 29 | "report" | "made" | "sector" |
| 30 | "provisions" | "general" | "social" |

*Explanations:* The table indicates words in a descending order of the probability that the words indicated belong to a given topic. Only thirty words receiving the highest posterior probabilities in each topic are included. The estimation gave the value 576.826 for "perplexity," measuring the predictive ability of the estimated model. However, it is not possible to assess if this is a high or low figure.

**Table 4**

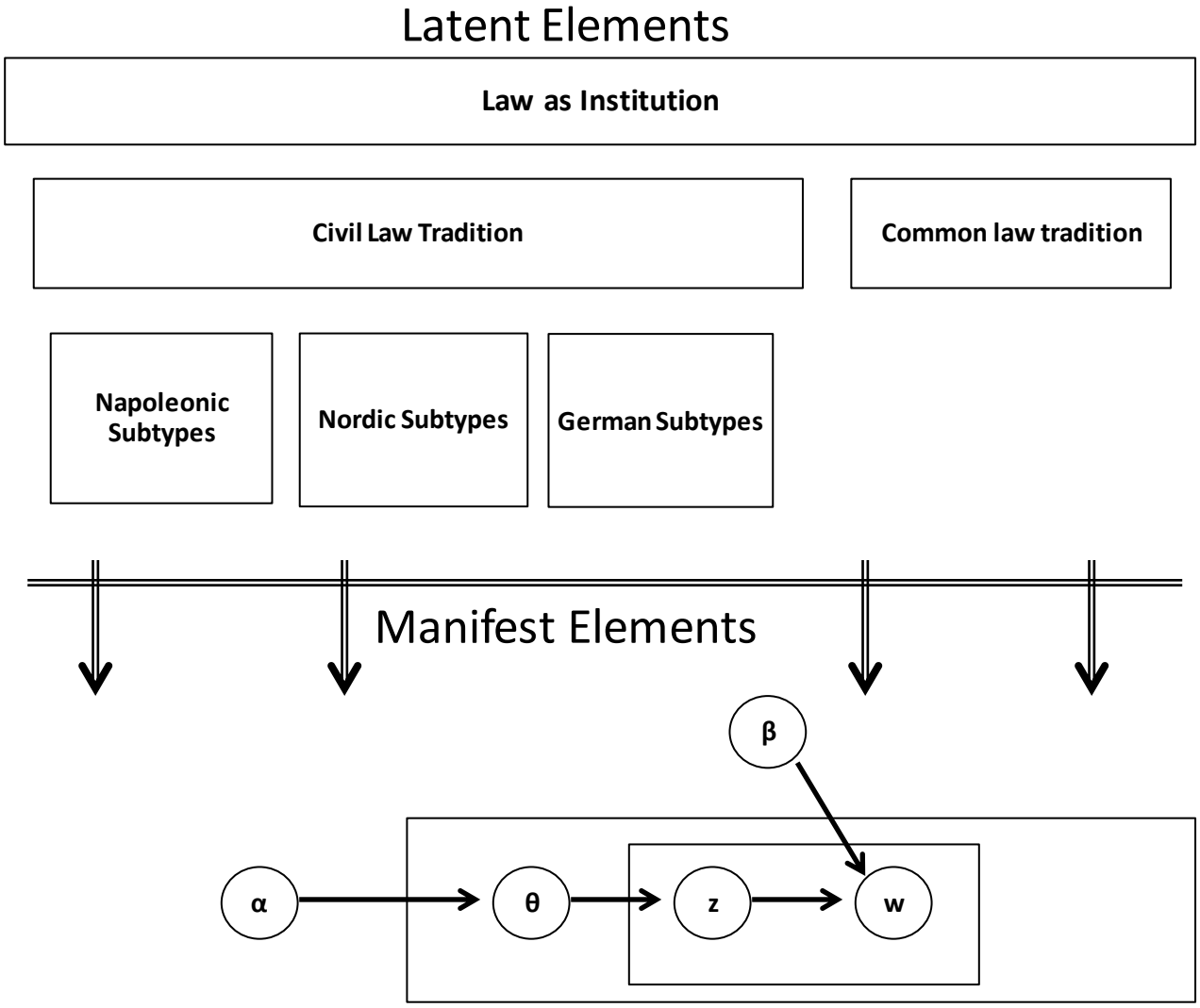
Distribution of Topics by Countries

| Countries | Topic 1, Heritage of the Nordic and German subtypes of the civil law legal system | Topic 2, Heritage of the common law legal system | Topic 3, Heritage of the Napoleonic subtype of the civil law legal system |
|---|---|---|---|
| Australia | 0.0000 | 1.0000 | 0.0000 |
| Austria | 1.0000 | 0.0000 | 0.0000 |
| Canada | 0.0000 | 1.0000 | 0.0000 |
| Estonia | 0.3078 | 0.0000 | 0.6921 |
| Finland | 0.9426 | 0.0000 | 0.0573 |
| France | 0.2109 | 0.0000 | 0.7890 |
| Iceland | 0.6364 | 0.0358 | 0.3278 |
| Italy | 0.0000 | 0.0000 | 1.0000 |
| Netherlands | 0.8176 | 0.1258 | 0.0566 |
| New Zealand | 0.0000 | 1.0000 | 0.0000 |
| Sweden | 0.9450 | 0.0000 | 0.0550 |
| Spain | 0.0000 | 0.0000 | 1.0000 |
| United Kingdom | 0.2815 | 0.5522 | 0.1663 |

*Explanations:* The figures in the table indicate the distribution of topics in the document or documents representing each country according to the posterior probabilities in the LDA (latent Dirichlet allocation) model estimated.

**Figure 3**

Outline of the Analysis Model of Government Budgetary Legislation in This Article




*Explanations:* The lower part of the figure, titled "Manifest Elements," reproduces the common graphical representation of topic modeling by means of latent Dirichlet allocation (LDA) (Blei et al. 2003). These elements manifest themselves in budgetary legislation used as the research material in this article. The letter w refers to words in documents, z to topics into which these words belong, θ to the topic distribution within a document, β indicates the probability distribution of words, and α refers to the Dirichlet prior for θ. The topic model estimation in this article has aimed to draw conclusions on what the figure names "Latent Elements," which have been expected to generate generating the manifest elements by mediation of what β and α represent. These conclusions have been derived from the estimation of the posterior distributions of the key variables by means of LDA.